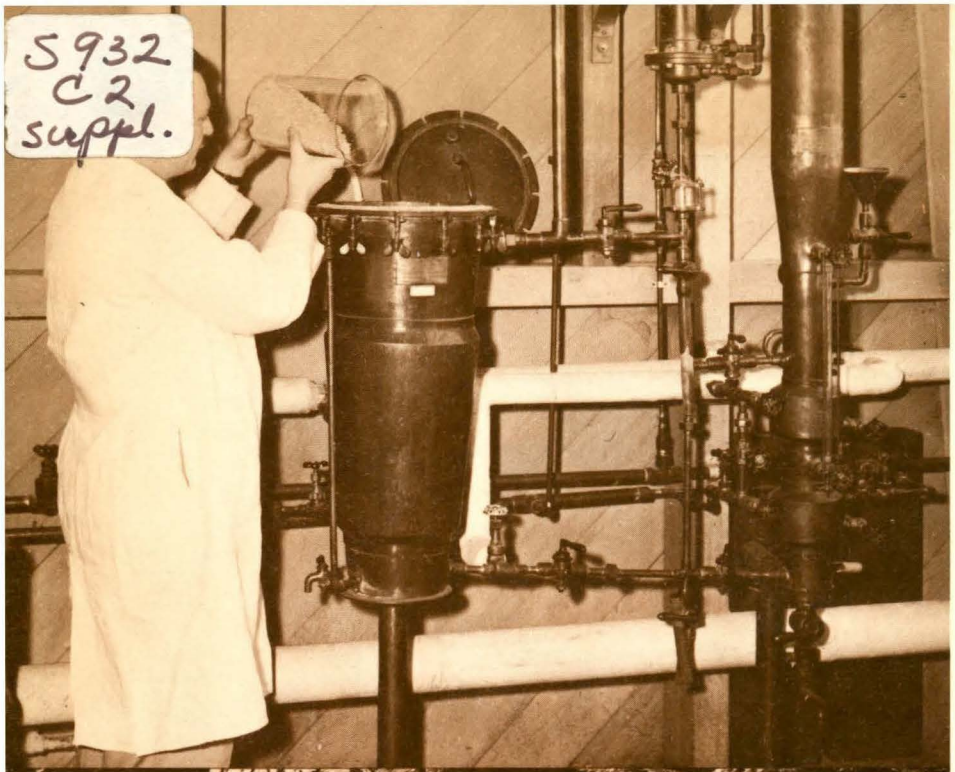
S932
C2
suppl.



WILDLAND RESEARCH PLAN FOR CALIFORNIA

. . . the key to better resource management

Supplement to Wildland Research in California

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF FORESTRY

in co-operation with

UNIVERSITY OF CALIFORNIA
SCHOOL OF FORESTRY

•

U. S. DEPARTMENT OF AGRICULTURE
CALIFORNIA FOREST AND RANGE
EXPERIMENT STATION
FOREST SERVICE, REGION 5

October, 1958

LIBRARY COPY
ROCKY MT. FOREST & RANGE
EXPERIMENT STATION

CONTENTS

	Page
The goal	2
The steps toward the plan	2
The research program	3
Forest fire research	4
Forest insect and disease research	4
Wildland soils research	4
Timber growing and harvesting research	5
Forest products research	5
Range management research	5
Watershed management research	6
Wildland recreation research	6
Wildland economics research	6
Needed financing	7
Appendix—the research needs in detail	9

FOREWORD

The research plan presented here was developed by a small group of men acting under the leadership of the California State Board of Forestry and in consultation with a cross-section of leaders in all phases of wildland management. The members of this group were carefully selected to secure within a small and workable committee broad knowledge and experiences as well as the appropriate state and national officials concerned with wildland management and research. The working group, which became known as the California Wildland Research Planning Committee, included:

Dean of the School of Forestry
University of California ..... Henry J. Vaux

Director of the California Forest and
Range Experiment Station
U. S. Forest Service ..... George M. Jemison
(succeeded by) Keith Arnold

Director of the Department of Natural Resources
State of California ..... DeWitt Nelson

Regional Forester
U. S. Forest Service ..... Charles Connaughton

State Forester
California Division of Forestry ..... Francis Raymond

Director of the California Forest
Products Laboratory
University of California ..... Fred Dickinson

Chairman of the California State Board
of Forestry ..... W. S. Rosecrans
(succeeded by) Wendell Robie

W. S. Rosecrans has acted as chairman of the Wildland Research Planning Committee.

. . . a comprehensive research program to insure future crops from California's wildland resources

California needs a co-ordinated, comprehensive research program to provide a sound scientific foundation for better management and richer yields from our wildlands. Productive wildlands make up 60 percent of our State's area. Extraordinary variations of climate and topography produce almost as many land types and vegetation problems here as in all the rest of the states combined. To provide the knowledge we need, research will have to be extensive, complex, and inevitably costly, but the great benefits at stake justify a California Wildland Research Plan.

California wildlands are richly endowed with some of the Nation's finest scenic and tourist attractions. Millions of people visit our forests and mountains each year. This use of the land creates a great many problems and complicates conservation and management: 14,000,000 Californians, plus great numbers of tourists, are putting pressure not only upon our recreational facilities but also upon water, forest products, forage, and fish and game. The pressure vastly increases the value of wildlands yet threatens the continued productivity of certain areas. Actually, the value of these wildlands is so great that it is impossible to place a figure on it. We can give accurate figures for the primary values of forest products; we can prepare good estimates for grazing, recreation, and fish and game. But who will attempt to place a value upon the water from our wildland watersheds? Without this water our multi-billion dollar economy could not have come into being.

This report presents a wildland research plan for California. Its program is comprehensive yet carefully balanced to give due weight to both present needs for knowledge and future potentialities of the entire State. It is the first plan to be prepared by any state which sets up a detailed program to provide the scientific knowledge essential for wise development, use, and protection of its wildland resources.

THE GOAL

THE STEPS TOWARD THE PLAN

Early in 1956 the California Wildland Research Planning Committee began its study of the problem involved in the development of a sound and comprehensive research plan. The first step was a very careful survey of the state of knowledge and research progress in California. A preliminary report, compiled for each of the major fields of research, indicated where knowledge is deficient. It also indicated in broad terms what had been accomplished in wildland research to date and appraised the present status of each research field. In February, 1958, the State of California published it with the title "Wildland Research in California–the Key to Better Resource Management."

Under sponsorship of the State Board of Forestry, the report was presented to representatives of a broad group of public and private agencies having a vital stake in the management of wildland resources throughout the State. After appropriate opportunity for study and evaluation by these agencies, and by several special groups concerned with wildland management and research, the committee carefully compiled an inventory of the research effort needed to provide a stronger base for management of our wildlands.

This compilation was then studied by research workers, wildland owners and administrators, and others directly concerned with the problems of wildland use. From such study came an assessment of the relative importance of the various research needs, and the proposed research

program was designed to meet those needs judged to be of the highest priority. (For a list of agencies consulted see appendix.)

Setting priorities for research was a critical step in developing the plan. Wildland management practice must be based on a wide diversity of major scientific disciplines. Without a balanced research effort in each discipline, lack of knowledge in a single area may greatly impair the practical usefulness of research results in a number of other areas. Therefore priorities were assigned only after careful study of both the potential which research offers for increasing the flow of goods and services from California's wildland, and the current state of knowledge in each research discipline. In certain research areas, the gap between existing knowledge and the requirements of current and prospective land management practice is much greater than in others. In some, the prospects for increased benefits from research are greater or more immediate than in others. The plan gives immediate high priority to the research which is most urgently needed to reverse the trend for management practices to outgrow the knowledge on which they are based. Thus this plan is geared to meet the needs for better information as the foundation for more fruitful and productive use and management of the State's vast wildland resource.

The figures in this report reflect more than two years of study by the research planning committee. But the plan represents much more than the collective judgment of the committee. It was aided by all agencies concerned with the conduct and application of wildland research. Specialists in both research and wildland management contributed generously of their time and knowledge, to make certain of a comprehensive appraisal of the status of knowledge in each field, to determine what needs to be done, and to pick the most critical needs for inclusion. The initial program described in the following pages, then, sets forth the research effort that management and research experience suggests is essential if our renewable natural resources are to satisfy the developing economic and social pressures for raw materials, outdoor recreation, and jobs.

THE RESEARCH PROGRAM

In summary, the California Wildland Research Plan identifies a program of needed research amounting to 4,826 man-months of work per year by qualified professional research workers (Table 1). Existing research is supplying 1,713 man-months of effort. High priorities are assigned to 1,444 man-months of effort. For successful research each such worker must, of course, be supplied with supporting statistical, clerical, and other staff and must have adequate research equipment and facilities. It is agreed that 1,669 man-months of recognized research needs can be temporarily deferred. Details of the types of studies needed in each major research area are outlined in the appendix of this report.

Table 1. SUMMARY OF EXISTING WILDLAND RESEARCH, RESEARCH NEEDS, AND PROPOSED PROGRAM FOR MEETING MOST CRITICAL NEEDS

(Entries show estimated research effort by professional workers in man-months per year)

Area of need	*Recognized research program needs*	*Recommended immediate program*			*Deferred needs*
		Existing research	*High priority additional needs*	*Total*	
	(1)	(2)	(3)	(4)	(5)
Fire	828	230	300	530	298
Insects	460	187	120	307	153
Disease	273	99	90	189	84
Soils	627	173	156	329	298
Timber growing and harvesting	679	182	240	422	257
Forest products	325	86	100	186	139
Range	623	345	102	447	176
Watershed	528	174	180	354	174
Recreation	139	103	36	139	0
Economics	344	134	120	254	90
Total	4,826	1,713	1,444	3,157	1,669

This is a current program. It reflects present needs and those future ones which can now be clearly seen. As research and economic development continue, needs will change. In the future the statewide research program must be responsive to such changing emphasis and scope as economic and social pressures dictate.

Forest Fire Research

The use of fire is perhaps the foundation of our civilization, yet after thousands of years, uncontrolled fire is still creating vast damage annually, causing great losses of life, improvements and natural resources. There is much about the nature of fire and its behavior that is still unknown. In our own State we are spending constantly increased sums for fire detection, prevention, and suppression. We have improved our organization, equipment, and fire-fighting techniques, but the losses in California's forests, range lands, and watersheds are far too great to assure conservation and good management.

Excessive fire losses in timber are a real deterrent to forest management because valuable young stands of trees are particularly liable to destruction. In a few hours fire may destroy the results of half a century of good management. Our valuable watersheds cannot continue their important function under the attrition they are suffering from fire. This is particularly true in areas where topography is steep and soils are excessively erodible. Forest fire research is essential to better and more economical fire protection and a key to better forest, range, and watershed management.

The committee has identified a need for 828 man-months of effort per year in forest fire research. Existing research facilities are providing 230 man-months, or just a trifle more than one-fourth of the total need. Research of high priority will require an additional 300 man-months annually. The balance of the needs, or 298 months, may be temporarily deferred.

Forest Insect and Disease Research

The damage done to forests by insects and disease is not as dramatic and immediately noticeable as the ravages of fire but in total may be—and often is—greater. Insects and disease destroy timber in an almost continuous attrition, with annual and cyclical variations. Damage is often unnoticed until too far advanced for effective and economic control. Insect or disease damage in a particular area may be slight or may suddenly flare into dangerous proportions. Such epidemics may be the result of changed conditions due to the use and harvesting of forest lands. Many epidemics rage for years without any apparent cause.

Present insect and disease research is of such a scale that it is mainly defensive. For example, new studies cannot be started to gather information on many pests, such as the needle miner in lodgepole pine and dwarfmistletoe in firs and pine, until the pests reach epidemic proportions. Research needs to be increased so that epidemic potentials can be forecast and biological and ecological controls established before damage is done, not after.

To do this kind of research on forest insects will take a total of 460 man-months annually. At present 187 man-months are being devoted to these problems. High priority is suggested for 120 man-months of new work. This work should be directed primarily to biological and ecological studies and to biological and chemical control. Such emphasis is most important at this time to develop management practices that will facilitate control.

Disease research shows total recognized needs of 273 man-months, and a present activity of 99 man-months. A total of 90 high priority man-months of research effort is suggested to strengthen this activity. The high priority studies would emphasize two fields of knowledge: the ecology of host trees and parasites in their own special environment, and methods of chemical and biological control.

Wildland Soils Research

Because of our extreme variations of climate and topography, California has numerous types of soil. Even in comparatively small areas, there may often be a number of soils of widely differing characteristics. Tillable soils have been mapped and studied for over half a century. Wildland soils until recently have had little attention. Many wildland soils are yet to be classified and many areas need to be inventoried. In deciding many problems of the management of wildlands, soil characteristics often constitute a determining factor.

The recognized need for soils research totals 627 man-months a year. Existing research facilities provide 173 man-months. A high priority is recognized for another 156 man-months. Additional emphasis is suggested on properties

of wildland soils, studies concerning the effect of wildland management practices on soil properties and soil behavior, and studies concerning soil manipulation practices useful in wildland management. A very substantial increase is recommended for characterization, classification, and mapping of soils and vegetation. It is felt that 298 man-months may be deferred at this time.

Timber Growing and Harvesting Research

Since timber harvesting was first started in California, about a century ago, regrowth on the land has been highly variable. We have some excellent stands of second-growth timber, some that are fairly good; but we also have about 1½ million acres of good forest land that has been harvested and on which there is either no young growth or inadequate stocking. This fact bears striking testimony of the difficulty of forest reproduction in California. The reasons are many; the foremost is our Mediterranean type of climate with a long dry summer period.

The problems of regrowing our timber, including those of establishing satisfactory young stands, developing improved types of trees, and caring for growing stock, are problems of vital importance to the future of the State of California. Full production of timber can provide jobs for new families besides raw materials for industry.

Recognized needs for research in timber growing and harvesting total 679 man-months a year. Existing research is taking care of 182 man-months of these needs. An additional effort amounting to 240 man-months rates high priority, and temporarily the remaining 257 man-months may be deferred.

Forest Products Research

The excellent results secured by the United States Forest Service at Madison, Wisconsin, in forest products research and the benefits it has returned to the Nation are well known. Because California had problems different from the United States in general, the need of special research in this area has been recognized by the State Legislature by the establishment of the California Forest Products Laboratory. A significant feature of this laboratory is its role in developing a research program responsive to the particular problems and needs of practical importance in California. Much important research in forest products is focussed on problems of producing, processing, and marketing highly manufactured items which are related only indirectly to problems of wildland management. These phases of forest products research have been excluded from the present program because primary responsibility for the conduct of it does not rest with those concerned with wildlands. But certain other areas of forest products research relate intimately and directly to wildland management problems. For example, improved utilization of certain hardwood species would do much to solve some silvicultural problems by creating markets for timber that cannot now be economically harvested.

Forest products research of direct relevance to wildland management includes a total need of 325 man-months; 86 man-months of this are now being carried out. It is recommended that 100 more man-months of high priority studies be added, and that 139 man-months be deferred temporarily.

Range Management Research

California was richly endowed with grazing lands. Early in our history, however, these lands were subjected to periodic overgrazing because of the cyclical variation of our rainfall and the incidence of occasional very dry years. This overgrazing has caused a serious problem of brush encroachment. The use of fire, bulldozers, and chemicals to remove brush, coupled with improved range management practices, is now beginning to increase the grazing capacity of California's wildlands. Good progress has been made within the last few years.

Out of a total recognized research need of 623 man-months, existing research now provides 345 man-months. There is a high priority need for 102 additional man-months. This additional research would deal primarily with range management systems for livestock and big game ranges, and with characteristics and measurements of range vegetation.

Watershed Management Research

California has always had water problems. Since World War II an unprecedented increase in population accompanied by increased overdraft of our ground water supplies has made California's water problems even more critical. The great and increasing demand for high quality, inexpensive water emphasizes the importance of watershed research, particularly when we realize that 95 percent of California's water comes from its wildland areas. There is little doubt that water will be a limiting factor to economic expansion in California.

Research must develop ways of increasing water yields from our watersheds, and at the same time find effective land management measures to reduce flood flows and to retard the silting of reservoirs. California's wildlands are a complex of soil patterns and topography—with extreme variations in vegetation and precipitation from one drainage to another and wide differences in land use in the valleys below. These conditions demand broad fundamental answers from watershed management research. The critical need is to know how variations in vegetation, topography, and soils interact in relation to water yield and soil stability.

To meet these watershed research needs completely would require a total of 528 man-months a year. Existing research meets 174 man-months of the need; 180 additional man-months are of high priority in the recommended program; temporarily 174 man-months may be deferred.

Wildland Recreation Research

The problems of wildland recreation are new in California. They have blossomed primarily because of increased population, rapid transportation, and the shorter work week. Our own population and our visitors, millions of people every year, spend much of their leisure time in our wildlands. This problem is growing so rapidly that careful study of it should be expedited.

At the present time, the recognized research needs total 139 man-months, and existing research includes 103 man-months. The remaining 36 man-months are of such high priority that they should not be deferred.

Wildland Economics Research

For the utmost in productive output and aesthetic values, there is almost no limit to the money which could be spent on the management of wildlands. But for practical action, we must know how much we can afford to spend without going beyond the point where the benefits of values protected and goods and services produced exceed their costs. Research in the economics of wildland use and management is needed to determine these limits. In addition, economic analysis helps to identify inefficiencies in our present ways of handling the wildlands and to point out what alternative methods may be more effective.

In the field of economics research there is a recognized need amounting to 344 man-months effort; 134 man-months of this is included in existing research. There is high priority for 120 additional man-months in the interest of economic wildland management. A further 90 man-months may be temporarily deferred.

NEEDED FINANCING

Research programs have price tags which are an essential part of the plan. To put into effect the high priority research program which the committee recommends will require an additional annual operating budget estimated at $2,050,000. The committee also estimates that a total capital outlay of $3,365,000 will be required.

Some current research is hampered because available funds do not provide adequate supporting facilities for the scientist. Since the supply of these professional research workers is critical, they must be used in an efficient and effective manner. Consequently, the operating budget for additional high priority research recommended in the plan is computed at an annual cost of $15,000 to $20,000 per full-time professional research worker. These levels of costs are based on present research experience and vary somewhat depending on the field of research (Table 2). They include salaries of the professional research workers, salaries of clerical and subprofessional personnel needed to assist research workers, and the necessary cost of supplies, equipment, and field travel needed for effective research. These financial goals are not suggested as a budget plan for any single public agency or group of agencies. Rather they set overall targets within which the several concerned agencies may effectively co-ordinate their research expenditures.

Expansion of the recommended scope will also require additional physical plant. To carry out the program, major new laboratories will be needed for research in fire and in soil, plant, and water relationships. Additional permanent field installation such as calibrated watersheds will be required. Small capital outlays will be needed for specialized equipment and space in almost all areas of research. On the basis of existing plans, currently anticipated needs for capital outlay are $3,365,000 (Table 3).

Table 2. ESTIMATE OF ADDITIONAL ANNUAL OPERATING COST REQUIRED TO FINANCE THE HIGH PRIORITY RESEARCH RECOMMENDED IN THE CALIFORNIA WILDLAND RESEARCH PLAN

Research area	*Recommended new research,*[1] *man-years*	*Estimated annual cost per man, dollars*	*Required additional annual operating cost, dollars*
Fire	25.0	20,000	500,000
Insects	10.0	15,000	150,000
Disease	7.5	15,000	112,000
Soils	13.0	15,000	195,000
Timber growing and harvesting	20.0	18,000	360,000
Forest products	8.3	17,000	140,000
Range	8.5	15,000	128,000
Watershed	15.0	18,000	270,000
Recreation	3.0	15,000	45,000
Economics	10.0	15,000	150,000
Total or average	120.3	17,000 (ave.)	2,050,000

[1] Derived from Table 1, column 4.

The division of these needed annual and capital costs between state and federal sources is complex and requires a balance between local and national responsibilities. The present annual operating budget for wildland research by all federal and state agencies in California is estimated at about $1.8 million. This is an approximate figure. Not all research can be clearly classified as to its bearing on wildland problems. Nor can

we determine accurately how much private individuals and corporations may be spending in this field. It is known, however, that current research by public agencies is financed 54 percent by federal funds and 44 percent by state funds. Besides the research private agencies conduct themselves, they and foundations contribute through grants-in-aid 2 percent of the financing of public agency research.

Table 3. ESTIMATED ADDITIONAL FINANCING REQUIRED FOR PROPOSED CALIFORNIA WILDLAND RESEARCH PROGRAM FROM STATE AND FEDERAL SOURCES

Research area	*Annual operating budget*		*Capital outlay*	
	Federal	*State*	*Federal*	*State*
Fire	$300,000	$200,000	$1,100,000	$60,000
Insects	50,000	100,000	20,000	90,000
Disease	56,000	56,000	20,000	50,000
Soils	45,000	150,000	10,000	75,000
Timber growing and harvesting	200,000	160,000	40,000	620,000
Forest products	25,000	115,000	.....	60,000
Range	64,000	64,000	.....	80,000
Watershed	150,000	120,000	900,000	185,000
Recreation	15,000	30,000	.....	15,000
Economics	50,000	100,000	.....	40,000
Total	$955,000	$1,095,000	$2,090,000	$1,275,000
Total, all sources	$2,050,000		$3,365,000	

In judging how to allocate the burden it must be recognized that some parts of the proposed research program provide information of nationwide value. Other parts have value primarily in California. Some parts deal with problems which are paramount on federally owned wildland, others with problems largely confined to state and private land. Certain public research agencies have already developed intensive work in particular fields and may thus present logical points for further expansion. With such guides as these in mind, operating costs are allocated about equally between Federal and State sources (Table 3). Because several of the needed research facilities will serve nationwide as well as State needs, it is recommended that a larger share of the capital outlay be allocated to Federal sources.

APPENDIX

THE RESEARCH NEEDS IN DETAIL

AGENCIES CONSULTED IN DEVELOPMENT OF THE WILDLAND RESEARCH PLAN

Society of American Foresters,
Committee on Forest Research
1000 Cypress Street,
Redding

Carter, Webster & Johnson, Inc.
P. O. Box 1731,
Stockton

R. L. Smith Lumber Company,
Anderson

Crown Zellerbach Corporation
343 Sansome Street,
San Francisco

Range Improvement Advisory Committee
State Board of Forestry

Shasta Forests Company
P. O. Box 898,
Redding

Setzer Forest Products
P. O. Box 1142,
Sacramento

Watershed Fire Council
530 W. Lancaster Blvd.,
Lancaster

California Forest Protective Association
681 Market Street,
San Francisco

Agricultural Experiment Station,
University of California
101 Giannini Hall,
Berkeley

California Redwood Association
576 Sacramento Street,
San Francisco

Redwood Region Conservation Council
222 Rosenberg Bldg.,
Santa Rosa

FOREST FIRE RESEARCH

A. Fire Prevention

Fire-prevention research outlined in the program will study the nature, cause, and possibilities of eliminating fire-starting sources of all kinds. It includes studies into the social, economic, moral, and psychological characteristics of people who cause forest fires. It will also develop yardsticks to measure the success or failure of prevention programs and determine the psychological effects of law enforcement and of prevention efforts. In addition, this research project must include basic studies in the classification of firebrands.

Lightning is another major cause of fires, and equally important in the program are studies aimed at gaining a better understanding of the atmospheric factors influencing the occurrence, behavior, and control of lightning. It also covers tests to determine the feasibility of preventing or reducing lightning fires through cloud modification.

B. Fire Control

Fire control research is made up of four main subjects: detection, behavior prediction, attack systems, and fire suppression techniques and equipment. Each of these is considered in the plan for forest fire research.

Detection studies include the evaluation of television, infrared, and other possible systems of finding fires. Evaluation and cost studies of the use of aircraft for detection are needed to determine their usefulness both for independent observations and for supplementing conventional ground systems. The ultimate goal is the detection and location of fires immediately after they start.

Behavior prediction includes studies to measure the factors affecting the rate and direction of fire spread, the intensity of burning, and blow-up potential for various weather, topographic, and fuel conditions. This includes the development and evaluation of fire-danger rating systems and fire-climate surveys to determine local wind patterns. Prediction of fire behavior also encompasses basic combustion studies of the physics and chemistry of fire.

Attack systems require a systematic analysis of the proper size and type of forces to be used against various fire situations. This work is needed to establish guidelines for developing an efficient initial attack system that will control most fires when small.

Techniques and equipment studies include the development, modification, and use of various tools and materials for the suppression of fires. Operational techniques are needed for such new firefighting tools as the helicopter, the air tanker, and chemical retardants.

C. Fire Use

The possibilities of using fire to aid in the care and management of wildland crops have been explored on a limited scale since the advent of fire exclusion policies. Much more information is needed on the techniques of executing "safe" and effective prescribed burns and for studies of the effects of fire and heat on soils and vegetation. Other studies will seek to learn the most desirable form and composition of vegetative cover and how this may be economically achieved through the use of fire.

D. Hazard Reduction

California has two major cover types in which hazardous fuel conditions are an important problem. These two types are so dissimilar in nearly every other respect that their separate treatment seems justified. They are the chaparral type watershed lands and the timber slash on cutover lands. Studies must include the development, testing, and evaluation of ways and means of breaking up or otherwise modifying expanses of brush to facilitate fire control. These studies should include physical, chemical, and biological approaches to the problem. In timber slash, studies are needed to develop methods and techniques for the reduction of slash on recently cut timber areas, keeping in mind the silvicultural and economic values and the risk and hazard involved.

E. Fire Economics

Economics enters into almost every problem concerned with fire. Too little is known about the relationship between the values protected and the costs of protection. Studies will include the establishment of values, either relative or absolute, of wildland resources so that protection priorities can be established. Also, they will compare protection methods in the light of the latest techniques and costs. Emphasis must be made on pointing out areas where the greatest potential gain may be expected. Fire damage appraisal systems which apply to areas of multiple use or of very intensive single use must receive strong consideration.

Table 4. NEEDED PROGRAM IN FOREST FIRE RESEARCH

(Man-months per year)

Study area	*Recognized research program needs*	*Recommended immediate program*			*Deferred needs*
		Existing research	*High priority additional needs*	*Total*	
	(1)	(2)	(3)	(4)	(5)
A. Fire prevention					
1. Man-caused fires	66	14	40	54	12
2. Lightning fires	94	46	12	58	36
B. Fire control					
1. Detection	30	0	12	12	18
2. Behavior prediction	337	85	114	199	138
3. Initial attack	54	12	24	36	18
4. Techniques and equipment	88	46	18	64	24
C. Fire use					
1. Management tool	24	0	6	6	18
2. Vegetation control	28	10	0	10	18
D. Hazard reduction					
1. Brushfields	45	9	30	39	6
2. Timber slash	14	2	8	10	4
E. Fire economics	48	6	36	42	6
Total	828	230	300	530	298

FOREST INSECT RESEARCH

A. Detection and Appraisal Surveys

Surveys include detection of outbreaks of native or introduced insects in their early stages; appraisal of insect-caused damage and the destructive potential of threatening infestations; periodic assessment of drain on forest resources from insects; development of information supplemental to biological and ecological studies (e.g., damage potential, distribution, hosts); and studies to improve survey methods.

B. Taxonomic Studies and Faunistic Surveys

Taxonomic studies define the insect species to be dealt with, reveal the characters by which each may be recognized, produce keys for separating species, and show relationships useful in other insect research. They form the foundation for all other lines of entomological study. Faunistic surveys show the distribution of insect species in the State.

C. Biological Studies

Research on insect biology covers studies of the life history and habits of insects, including studies of life stages, their occurrence, location and duration; studies of range, host plants, and part of plant affected; and studies of the character of insect work and its general effect on the host. These studies reveal how an insect pest exists, how it causes damage, and where in its life cycle it is most likely to be vulnerable. They also indicate what control measures may be successful and when they should be applied. This information is prerequisite to preventing or curtailing insect damage most effectively.

D. Ecological Studies

Ecological studies look into the environmental factors that affect the behavior of insects and insect populations. This research program includes studies of the reaction of individual insects to their environment, studies of the dynamics of population buildup, factors regulating populations, such as host plants, competition, or other biological organisms, degree of artificial regulation needed for effective control, and the effects of micro-organisms and climate on host environment. From these studies the combined effect and relative importance of various ecological factors can be determined. They also shed light on the underlying causes of outbreaks, show when they may be developing and how they may be prevented. Knowledge of this type is necessary to the development of more effective silvicultural control.

E. Physiological and Nutritional Studies

Research on the physiological requirements of insects for food and moisture will include studies of insect responses to stimuli from odors, tastes, and moisture associated with the host and studies of the role of micro-organisms in relation to insects' responses and nutritional needs. Information of this type is needed to understand the behavior of individual insects. It can help explain such phenomena as host specificity, variation in individual tree susceptibility, and variability in brood development. It is required for perfecting silvicultural, biological, and chemical control measures, and is of value in certain types of population surveys.

F. Biological Control

Biological control involves studies of the natural enemies (both disease and other insects) that attack forest insect pests, to determine the possibilities of using these natural enemies as control agents. These control studies will include surveys to determine the kinds and abundance of the enemies of major pests and to evaluate their effectiveness; studies to develop methods of fostering specific natural control agents found to be promising; field tests of these agents; and importation of natural enemies of foreign origin. The possibilities of biological agents for controlling most forest pests are largely unknown; viruses have been used successfully in controlling some forest defoliators. These studies would fill this gap and perhaps provide potent new control methods for some major pests.

G. Chemical Control

Chemical control involves investigations of chemicals for controlling bark beetles and other forest insects. It will include studies to establish toxicity indices of residual insecticides and will determine the factors that influence the effectiveness of residual sprays. Another phase will study the development of resistance to insecticides in bark-beetle populations. Studies of the potentialities of systemic insecticides are needed, as are studies to improve and develop methods of applying chemicals for protecting forest trees and wood products from insect attack. Information of this type will help to perfect more effective, cheaper, and safer means of using chemicals in controlling insect pests.

H. Silvicultural Control

Silvicultural control studies seek to develop methods of preventing or minimizing insect damage through forest management practices (e.g., sanitation-salvage, logging windthrow, lightning-struck, and fire-injured trees). Such studies will establish criteria for recognizing trees most susceptible to insect attack; relationship of slash to insect damage; influence of silvicultural and management practices on insect problems; and the testing of these practices to determine how they may be used most effectively for insect control. Much can be done through silviculture to minimize damage by forest insect pests. Studies in this field are needed to show the extent to which silvicultural methods can be relied upon for controlling damage by major pests in various forest types.

Table 5. NEEDED PROGRAM IN FOREST INSECT RESEARCH

(Man-months per year)

Study area	*Recognized research program needs* (1)	*Recommended immediate program*			*Deferred needs* (5)
		Existing research (2)	*High priority additional needs* (3)	*Total* (4)	
A. Detection and appraisal surveys	66	42	0	42	24
B. Taxonomic and faunistic surveys	21	9	0	9	12
C. Biological studies	110	32	48	80	30
D. Ecological studies	96	48	24	72	24
E. Physiological and nutritional studies	26	2	12	14	12
F. Biological control	37	19	12	31	6
G. Chemical control	69	27	24	51	18
H. Silvicultural control	29	8	0	8	21
Economics of insect control	6	0	0	0	6
Total	460	187	120	307	153

FOREST DISEASE RESEARCH

A. Detection and Appraisal Surveys

Disease surveys complement insect surveys and provide statewide detection and appraisal of forest tree diseases in the several forest types of California. The surveys include qualitative and quantitative on-the-ground inspections of diseases reported by state, private, and federal co-operators and on sample plots. The research program in the plan includes studies to improve survey methods and to accelerate compilation of data on drain on forest resources from diseases. Information gathered in this work aids in planning control and points to research needs.

B. Mycological and Taxonomic Studies

Mycological and taxonomic studies identify the organisms responsible for forest diseases, develop methods of distinguishing these pathogens, and work out their life cycle and inter-relationships. Effective damage appraisals, field research, and control methods depend on the accuracy with which diseases with similar symptoms can be distinguished. The development of rapid, accurate keys to forest fungi greatly reduces the amount of time necessary to make positive identifications.

C. Ecological, Environmental, and Host-parasite Studies

A basic element of the research program is study of the sequence of events in the life cycle of the pathogen and of the post plant which leads to disease development. This work also seeks to learn how the environment modifies or affects this sequence of events and how the host, pathogen, and environment interact. Other information these studies will pin down includes: spore (or seed) production, dissemination, germination, and penetration of the host; the conditions which predispose the host to infection; the changes in metabolism and structure of the host which result in damaging symptoms; the defense mechanisms of the host; and the influence of environment on these stages of disease development. Once these relationships are clearly understood, the vulnerable stages of disease development can be attacked by silvicultural manipulation, by elimination of predisposing factors, or by direct biological or chemical controls.

D. Noninfectious Diseases

Noninfectious diseases include tree damage from adverse environmental factors such as frost, ice, snow, heat, drought, wind, or industrial fumes. The research program will develop methods of diagnosing such ailments. It will also define the criteria by which hazardous sites can be recognized and by which damaged stands can be salvaged, and it will determine the means by which damage may be minimized through changes in management practices.

E. Chemical and Biological Control

To reduce damage from forest tree diseases, the plan includes studies on the use of contact and systemic herbicides and fungicides for the control of host plants and of disease organisms in the tree or soil. This research area includes surveys to determine the kinds and abundance of competitive organisms that might control major pests; and it provides for the location, selection, and testing of disease-resistant tree species. These studies directly aid going control jobs and suggest new and improved methods.

F. Silvicultural Control

Silvicultural control studies will test the usefulness and costs of preventing or minimizing disease losses through managerial practices, such as sanitation logging, pruning, slash disposal, thinning, prescribed burning, and species alternation. The research will develop criteria for appraising the probable impact of diseases on management and protection work in various forest sites. Demonstration areas are included as part of the program to aid in application of research findings. Many diseases are expensive or impractical to eradicate but might be reduced to the status of a minor pest by sound silvicultural methods.

Table 6. NEEDED PROGRAM IN FOREST DISEASE RESEARCH
(Man-months per year)

Study area	*Recognized research program needs*	*Recommended immediate program*			*Deferred needs*
		Existing research	*High priority additional needs*	*Total*	
	(1)	(2)	(3)	(4)	(5)
A. Detection and appraisal surveys	52	26	8	34	18
B. Mycological and taxonomic studies	46	20	12	32	14
C. Ecological, environmental, and host-parasite studies	74	26	42	68	6
D. Noninfectious diseases	13	1	6	7	6
E. Chemical and biological control	52	16	22	38	14
F. Silvicultural control	30	10	0	10	20
Economics of disease control	6	0	0	0	6
Totals	273	99	90	189	84

WILDLAND SOILS RESEARCH

A. Properties of Wildland Soils

Knowledge which is fundamental for most wildland management decisions is to be gained from studies which measure the kind and magnitude of properties of soils found in wildland areas. Such information is, in turn, fundamental for much other research on effects of management and soil manipulation.

B. Characterization, Classification, and Mapping of Soils and Vegetation

Investigations into kinds of soils and vegetation, their relationships, and their distribution provide a powerful management tool. They determine standard physical, chemical, and morphological characteristics of soils and the composition and

density of vegetation and characteristics of timber stands. These investigations include standard tests of soil fertility, determination of timber site index, and appraisal of the erodibility, moisture-holding capacity, and permeability of different soils. They provide estimates of suitability for various uses—particularly for timber production and range forage production under extensive management. And they show the general mechanical characteristics of different soils that affect road construction.

C. Effect of Management Practices on Soil Properties and Soil Behavior

The research program will study changes brought about by various land management practices, such as range or forest management, on soil properties, and the effects of these changes on soil behavior and on the subsequent management of the soil for the desired or alternate uses.

D. Studies Concerning Soil Manipulation Practices Useful in Wildland Management

There is a need for the development of techniques of manipulating the soil to obtain desired results consistent with the objective of the wildland manager—whether this be the production of a forage or a timber crop or some other use. These soil manipulation techniques will include fertilization methods, soil and site preparation procedures for various purposes such as achieving forest regeneration or range reseeding, manipulation of soil needed to obtain certain engineering objectives such as road fill construction, etc. These soil manipulation procedures must be specific for certain categories of soils.

Table 7. NEEDED PROGRAM IN SOILS RESEARCH
(Man-months per year)

Study area	*Recognized research program needs*	*Recommended immediate program*			*Deferred needs*
		Existing research	*High priority additional needs*	*Total*	
	(1)	(2)	(3)	(4)	(5)
A. Properties of wildland soils	98	20	34	54	44
B. Characterization, classification and mapping of soils and vegetation	376	132	67	199	177
C. Studies concerning the effect of wildland management practices on soil properties and soil behavior	78	6	27	33	45
D. Studies concerning soil manipulation practices useful in wildland management	75	15	28	43	32
Total	627	173	156	329	298

TIMBER GROWING AND HARVESTING RESEARCH

A. Forest Tree Improvement

Genetic studies seek to determine: (a) the nature and extent of variation in form and function within species; (b) the inheritance of characters; (c) what species can be crossed and the character of hybrids produced. Major emphasis on the genetics of the pines should continue but expansion of studies to other important genera is also needed.

Physiological and biochemical studies will be included in the research program to determine the basic factors that affect or control the physiological processes involved in or associated with (1) flowering and sexual reproduction in trees, and (2) asexual reproduction in trees through rooting of shoots. Information about the factors or conditions essential to flowering and sexual reproduction are needed to enable workers to bring young trees of many species into vigorous reproductive activity and to cause them to flower and reproduce regularly and abundantly. This will, in turn, speed up genetic research and breeding and the practical application of products of breeding.

B. Improved Seedling Establishment

Natural regeneration studies are an important phase of reforestation research. These include determination of (1) habitat conditions required for successful germination, survival, and growth of all commercially important timber species, (2) methods for eradication of brush cover—mechanical, chemical, and fire, (3) how to induce more abundant seed crops, and (4) how to reduce destruction of seeds by seed-eating rodents and other animals.

A second phase, direct-seeding studies, includes research to learn: (1) the physiology of seed ripening and the requirements for effective storage and germination of tree seed; (2) the best sources of seed to plant in different localities; (3) if laboratory tests of items 1 and 2 can be confirmed by field tests; and (4) how to prevent damage by rodents to planted seed. Development of effective direct-seeding techniques could materially hasten the rehabilitation of deforested land.

A third part of this program will study production of planting stock and subsequent field planting. These studies will determine: (1) the best physiological condition of nursery propagated trees at the time of field planting; (2) the optimum spacing of trees and soil fertilization in nurseries; (3) specifications for desirable planting stock; (4) how to eradicate undesirable vegetation from planting sites; and (5) how to prevent injury to planted trees by animals, especially porcupines and deer.

C. Manipulation of Growing Stock

For all major forest types, studies are needed to attain high production in volume and quality. These studies include: (1) development of final and intermediate harvest cutting systems; (2) determination of optimum size of openings to stimulate natural regeneration; (3) finding spacing and quality standards that will produce the maximum growth; and (4) development of thinning, pruning, and releasing methods including the removal of unwanted growth.

D. Prediction of Growth and Yield

The research plan will develop techniques for accurately forecasting timber growth and yield in both residual old-growth and young timber stands, whether essentially pure or of mixed species. Growth refers to increase in diameter, basal area, height, volume, quality, or value of individual trees or stands in relation

to time. Yield tables show the stand's development at periodic intervals covering the range of age for species on given sites. These tables may include information on average diameter and height, basal area, number of trees, volumes of thinnings and final cuts. But before yield tables can be compiled, usable site classifications must be defined. Site, growth, and yield data are essential tools used to decide forest land management policies.

E. Methods of Timber Harvesting

Timber harvesting studies will search for better techniques of planning harvesting processes and studying their costs. They measure the effects of harvesting on soil characteristics and productivity of residual stands. They compare the performance of various types of equipment as related to silvicultural-management requirements in both old-growth and young-growth stands, and they determine costs of timber extraction by various types of equipment, including the effects of more intensive silviculture.

Table 8. NEEDED PROGRAM IN TIMBER GROWING AND HARVESTING RESEARCH

(Man-months per year)

		Recommended immediate program			
Study area	*Recognized research program needs*	*Existing research*	*High priority additional needs*	*Total*	*Deferred needs*
	(1)	(2)	(3)	(4)	(5)
A. How to develop satisfactory growing stock, forest tree improvement	148	48	66	114	34
B. How to establish satisfactory growing stock	274	81	90	171	103
C. Manipulation of growing stock	112	36	36	72	40
D. Prediction of growth and yield	95	15	36	51	44
E. Methods of timber harvesting	50	2	12	14	36
Total	679	182	240	422	257

FOREST PRODUCTS RESEARCH

A. Physical and Mechanical Properties of California Species

Wood-properties research includes determination of standard strength data, information on fastenings, and such physical properties as shrinkage and other wood moisture relations including wood drying. Of importance is the development of testing procedures to enable the gathering of information which will be of maximum value to both forest manager and producer.

B. Wood Chemistry

Chemical studies should determine the chemical composition of California woods, and analyze each species to determine the amount and nature of extractives, cellulose, hemicellulose and lignin. The work should also develop methods of converting woods to useful chemical products.

C. Wood Fiber and Wood Particle Products

A research program aimed at diversifying the output of timber products must include at least three phases. One would determine the pulping characteristics of California species, study methods of wood pulping that require little or no water, and seek ways to eliminate pulping effluents. A second phase would investigate the quantity of wood residues available at mills after primary manufacturing and in the forest after logging. A third class of studies would develop methods of using the residues for particle boards and fiberboard and look for ways to improve these products.

D. Processing of Wood

Research in the mechanical and chemical processing of wood is needed to improve both manufacturing methods and the end product.

E. Wood Protection

Studies of ways to protect wood against deterioration due to fungi, insects, fire, and the elements can improve the competitive position of timber products.

F. Brush Species Utilization

Studies of the potential products that can be made from brush species may open up new uses for a cover type often considered of little direct value. The research should include investigation of the economics of raw material procurement and manufacture.

Table 9. NEEDED PROGRAM IN FOREST PRODUCTS RESEARCH

(Man-months per year)

		Recommended immediate program			
Study area	*Recognized research program needs*	*Existing research*	*High priority additional needs*	*Total*	*Deferred needs*
	(1)	(2)	(3)	(4)	(5)
A. Physical and mechanical properties of wood	117	43	32	75	42
B. Wood chemistry	48	18	12	30	18
C. Wood fiber and wood particle products	60	—	36	36	24
D. Processing of wood	75	25	20	45	30
E. Wood protection	12	—	0	—	12
F. Brush species utilization	13	0	0	0	13
Total	325	86	100	186	139

RANGE MANAGEMENT RESEARCH

A. Managemnt Systems for Livestock and Big Game Ranges

The development of improved, new systems, and the testing of existing one such as rotation, deferred, yearlong, and rest-rotation grazing, are essential features of research on livestock and big game ranges. Responses should be evaluated in terms of vegetation and animal production and in trend of range condition. Wherever

possible an analysis of costs and returns should be made. Similarly, grazing under each system should be fully correlated with other land uses and values.

B. Improvement Practices for Grass and Brush Ranges

The development and testing of range improvement practices is largely concerned with seeding, fertilization, and the manipulation of existing undesirable vegetation with fire, chemicals, and mechanical and biological means. This includes the search for new species and varieties of plants, the testing of their adaptability to various sites and conditions, and the development of suitable seeding practices. Research with fertilizers on range lands involves the determination of the optimum time of application and the amount required for sustained high forage and animal production by sites and soil types. Similarly type conversion involves the discovery and testing of chemicals and means of application, uses of fire, mechanical devices, and biological agents which will be effective in reducing or removing and controlling undesirable vegetation and in encouraging desirable plant species. The greatest need is to develop specifications for each practice as to where, when, and how it should be used.

C. Livestock-wildlife-vegetation Relationships

Studies will be included to determine how domestic livestock and wild animals may be managed together on the same areas and what their interrelationships with the vegetation are. Some of the problems to be studied are: the effects of rodents on vegetation, how to control destructive insects and encourage beneficial ones, the effects of animals on watersheds, and how to reduce damage to tree reproduction by grazing animals.

D. Characteristics and Requirements of Range Vegetation

Use and management of range vegetation to its full efficiency depends upon adequate knowledge of the interrelationships between plants and their environment. Work in this research area includes studies on the requirements of species for heat, moisture, and nutrients; the nature of competition between plants; vegetational changes both natural and induced by man's activities; and the genetics of the important plants. These plants provide forage; therefore, studies must be made of their nutritive values and digestibility by livestock and game. Vegetation is a complex assemblage of plants and much work is needed on methods of sampling so that adequate data can be obtained with a minimum of effort.

Table 10. NEEDED PROGRAM IN RANGE MANAGEMENT RESEARCH
(Man-months per year)

Study area	*Recognized research program needs*	*Recommended immediate program*			*Deferred needs*
		Existing research	*High priority additional needs*	*Total*	
	(1)	(2)	(3)	(4)	(5)
A. Management systems for livestock and big game ranges	86	18	66	84	2
B. Improvement practices for grass and brush ranges	236	176	0	176	60
C. Livestock-wildlife-vegetation relationships	147	63	0	63	84
D. Characteristics and measurements of range vegetation	154	88	36	124	30
Total	623	345	102	447	176

WATERSHED MANAGEMENT RESEARCH

A. Watershed Management in California Brushlands

To develop more effective management of brushlands will require watershed hydrology studies of climate and precipitation, water yield and sedimentation, infiltration and evaporation. These basic studies must be followed up with trials of management of watershed slopes and stream courses dealing with vegetation manipulation, slope and channel stabilization, and treatment of burned watersheds and road slope stabilization.

B. Watershed Management in California's Snow Zone

Snowpack research includes: (a) studies of meteorology and snow accumulation and melt; (b) studies to determine the amount and timing of water yield from various parts of watersheds; (c) studies of the effect of forest types and sites on water yield; (d) development of methods of increasing water yield, delaying water yield, minimizing sedimentation and local floods, and maintaining water quality; and (e) pilot tests of promising watershed management measures on whole watersheds to measure the effects of management on streamflow and sedimentation.

C. Watershed Management in California's Commercial Timber Zone

Both basic and applied studies are needed in commercial timber, too. They include: (a) studies of precipitation, soil moisture regime, sedimentation, and streamflow on experimental watersheds; (b) studies of the effect of forest stands, fire, and cutting, on water yield and flood flows; (c) studies of the water yield; (d) development of watershed management methods for increasing water yield, delaying water yield, minimizing sedimentation and local floods, and maintaining water quality; and (e) pilot tests on whole watersheds of promising watershed management measures.

Table 11. NEEDED PROGRAM IN WATERSHED MANAGEMENT RESEARCH
(Man-months per year)

Study area	*Recognized research program needs*	*Recommended immediate program*			*Deferred needs*
		Existing research	*High priority additional needs*	*Total*	
	(1)	(2)	(3)	(4)	(5)
A. Brushlands	204	78	66	144	60
B. Snow zone	204	96	42	138	66
C. Commercial timber zone below the snow zone	120	0	72	72	48
Total	528	174	180	354	174

WILDLIFE RECREATION RESEARCH

A. Research in Recreational Land Management

Recreational land management research includes studies and analyses of the alternatives open to managers of particular recreational areas, public or private. The work rests on the assumption that the particular areas under study have already been dedicted to recreation use—either under a single use policy or under multiple use. Studies concerned with merits of different land uses, i.e., recreation vs. water vs. timber, are more properly in the province of forest economics research. However, forest recreation studies in this category are necessary to provide some of the input-output data required for economic analyses of land-use alternatives.

B. Research in Recreational Policy, Institutions, and Economics

Research in recreational policies, institutions, and economics is of major significance to public decision makers, to managers of large private wildland holdings, and to the recreation industry as a whole. This research will also be of value to individual firms in the recreation industry, particularly in choosing the location and scale of operations. The problems in this field are concerned mainly with the characteristics of demand for recreation services and facilities and with the nature and variability of the factors affecting such demand. For example, it is not enough to know that 100,000 people would be willing to spend $50 apiece for an occasional weekend of skiing and that 40,000 would willingly spend $100. The policy maker must also determine how many want beginners' slopes and how many want expert slopes. He also wants to know how many actually want to ski and how many merely wish to watch others ski; how many will provide their own facilities overnight and how many will need public accommodations; how much parking space will be necessary, how many lifts will be required, how many children must be provided for, how distribution of ski resorts will affect demand, and when and where peak use of facilities might occur.

Table 12. NEEDED PROGRAM IN WILDLAND RECREATION RESEARCH
(Man-months per year)

Study area	*Recognized research program needs*	*Recommended immediate program*			*Deferred needs*
		Existing research	*High priority additional needs*	*Total*	
	(1)	(2)	(3)	(4)	(5)
A. Recreational land management	85	63	22	85	0
B. Recreational policy	54	40	14	54	0
Total	139	103	36	139	0

WILDLAND ECONOMICS RESEARCH

A. Collection of Basic Economic Statistics

More detailed and more localized statistics of timber volumes and growth, and of industry output and trends are needed. These would permit more accurate appraisal of business and economic problems and hence more effective action to solve such problems.

B. Economics of Production

Before the new techniques developed by research can be effectively applied in wildland management practice, the costs and returns of using them must be known. Studies of the economics of production are essential if wise choices among various alternative methods of management are to be made.

C. Analysis of the Wildland Economy

1. Marketing and utilization. Studies of markets and of the economics of ultilization are needed as a foundation on which to build new and enlarged markets for existing wildland products and for residual materials which remain unutilized under current market conditions.

2. Taxation, credit, and insurance. Taxation, credit, insurance, and related institutions often have very important impacts on the way wildlands are managed. Particularly in view of the strong influence of public policies on these institutions, research is needed to make certain that such policies do not unnecessarily obstruct good management practices.

3. Demand for wildland products. Because of the long time period involved in production of timber and certain other wildland products, careful and continuous appraisal of the factors affecting demand for these products and of the long-term trends in such demand is needed. Such appraisals provide essential foundations for such key decisions as the best use of land, the proper intensity of management and protection, and the wise limits of investment in wildland conservation activities.

D. Wildland Benefits and Costs to the Economy at Large

Whether or not newly developed techniques are really better than what we are already doing depends on whether or not the additional benefits resulting from the new practices exceed the additional costs of putting them into effect. In addition to direct financial costs, attention must be given to broader economic consequences such as nonmonetary benefits and costs, and the effects on employment, wages, incomes, and tax revenues. This type of analysis is particularly essential for proper evaluation of public programs dealing with wildland protection and management.

Table 13. NEEDED PROGRAM IN WILDLAND ECONOMICS RESEARCH
(Man-months per year)

Study area	*Recognized research program needs*	*Recommended immediate program*			*Deferred needs*
		Existing research	*High priority additional needs*	*Total*	
	(1)	(2)	(3)	(4)	(5)
A. Collection of basic economic statistics	120	72	24	96	24
B. Economics of production	93	15	60	75	18
C. Analysis of the forest economy	81	33	24	57	24
D. Wildland benefits and costs	50	14	12	26	24
Total	344	134	120	254	90

88517 12-58 5M

printed in CALIFORNIA STATE PRINTING OFFICE